

REMARKS

This amendment is believed to put the application in condition for allowance.

Applicants appreciate the interview held between the Examiner and undersigned attorney as well as the kind suggestions offered during the interview.

The specification has been reviewed as to form to correct obvious errors and to improve clarity. A substitute specification together with a marked-up copy are enclosed. The undersigned attorney verifies that no new matter is being entered by way of this substitute specification submission.

Amended drawing sheets 1-4 are enclosed. On sheet 1, Figure 3 is amended to remove the identifier 11, Figure 4 to add the identifier 11, and Figure 9 to remove identifier 33. On sheet 2, Figure 7 was amended to remove identifier 33. On sheet 3, Figure 11 was amended to add identifier 7 and change identifier 27 to 85, and Figure 12 to add identifier 35. On sheet 4, "Fig." was changed to Figure and the upper view has been restored.

The Official Action rejected previously pending claims 35-46 and 54-66 under §103 as obvious over SAETHER 4,611,757 in view of SCHEUERMANN 3,987,819.

Previously pending claims 47-53 were rejected in further view of KIENDL 4,558,817.

Various of the previously pending claims were also rejected under §112, first paragraph. These claims have been cancelled.

The previously pending claims have been replaced with claims 67-92 believed to patentably recite the present invention and overcome all the pending rejections.

The newly-presented claims have been drafted so as to be both novel and non-obvious over these applied references as well as all prior art to which applicants are aware. Accordingly, reconsideration and allowance of all the pending claims are respectfully requested.

Note that an IDS was filed on May 6, 2004. These references are discussed below.

The invention includes a mixing valve having only one moving disk with only one axis of motion. The design of this single moving disk arrangement is able to achieve both mixing control and flow on/off control, while at the same time achieving a considerable reduction in the actuator driving force required to move the disk, e.g., allowing use of a small stepper motor.

These features have produced a valve which has proven to be compact, having few moving parts, and particularly suitable for scaling up to suit industrial applications. The valve is proving to be particularly effective in many industrial mixing applications, and is showing particularly good reliability. The

following explanation sheds light on the advantageous features of the invention.

While many domestic disc valves have used two moving disks, one to control flow rates (on/off control) and the other to control temperature (mixing control), the present invention provides a valve having only one axis of movement, and only one moving disk which is simpler, cheaper and more reliable. Further, such a valve requires only one actuator. See claim 92 specifically.

The inventors produced a disk design having one fixed disk with two side by side apertures (suitable as an inlet side valve seat; see e.g., Figures 1 and 5), and one movable disk having a single aperture (e.g., Figure 3). The two apertures on the fixed disk may be 90 degree sector shapes and the single aperture in the movable disk may be a 120 degree sector shape. In each case the sectors extend from as close as possible to the center of the disk to as close as possible to the perimeter of the disk, while still allowing surface area about the apertures for sealing. Such an arrangement gives a relatively linear relationship between temperature and movable disk rotation. This feature makes the invention well suited to a feed-back control system.

To achieve fast and accurate control of mixed water temperature, even when supply pressures fluctuate, sensing mixed water temperature provides the most accurate results. A

microprocessor based electronic control system receiving feedback from an outlet pipe temperature sensor provides an effective system. A stepping motor may be chosen as a suitable actuator to interface with such a control system. This provides a low cost, accurate and reliable valve with minimal installation difficulties. A simple electronic user interface may be incorporated to allow a user to control temperature settings.

To meet constraints of size, so that the valve would fit within a wall cavity, and constraints of cost, a relatively small and very low cost stepper motor is desirable. To be able to utilize such a stepper motor, the present invention minimizes friction between the discs to reduce loading on the shaft which turns the rotatable disk.

The present invention provides the following improvements over the prior art:

**1) Minimised disk diameter.** Most of the previous mixing valves had relatively large disk diameters compared to aperture size. These designs clearly worked where operating torque was not a concern, for example in hand operated valves, where the torque generated by a person pushing against a lever is far greater than that available in a low cost stepper motor.

As the diameter of a disk increases, the surface area increases exponentially, as does the torque required to rotate two disks relative to each other when friction or stiction forces are preventing the movement. The invention provides a pair of valve

discs that would allow the maximum flow of two separate water supplies, while at the same time give the minimum disk diameter, and yet also enable the flow to be shut-off.

To maximise through flow for a given disk diameter the invention teaches to size and position the sector shaped cutouts such that the apex of the sector shapes were as close as possible to the center of the disk, and the arcs of the sector shapes were as close as possible to the perimeter of the disk.

**2) Through Flow.** Disks which allowed a through path for the water are more efficient in allowing the disk diameter to be minimised since there is no requirement to put a return path in the valve seat disk. A through flow does produce a requirement for additional sealing about the drive spindle.

**3) Optimised inlet aperture sizing.** Large inlet apertures expose significant area of the contact surface of the movable disk to inlet pressure. This pressure, particularly in a shut-off configuration, produced loads on the drive spindle bearings which contributed adversely to the overall torque requirements of the valve. The inventors noted that, in practice that the movable disk operated mainly in the range 33% cold and 67% hot to 67% cold and 33% hot. An optimised inlet aperture geometry reduces the area of the movable disc that was exposed to inlet pressure but still allow the valve to work without any flow loss within the most useful range, that of 33% cold and 67% hot to

67% cold and 33% hot. This geometry was inlet apertures having sector shapes with an apex angle of about 90 degrees.

To allow space on the disk for the shut-off configuration the invention situates the two inlet apertures adjacent to one another.

**4) Minimised exposure of the valve seat disk to inlet pressure.** Inlet pressure has the effect of pushing the two disks together, tending to increase the torque requirements to move one disk relative to the other. To minimise these forces, the cross sectional area of the inlet aperture is slightly reduced on the face of the valve seat disk opposite the contact surface with the movable disk. Also seals were minimise the contact of inlet pressure to the smallest possible area about the inlet aperture.

This arrangement provides inlet apertures in the valve seat disk which were circular in cross section on one side of the disk, and 90 degree apex sectors on the opposite side, with a smooth transition between these two shapes through the thickness of the disk.

**5) Minimised contact area between the disks.** While it is necessary for a good deal of contact to exist between the valve seat disk and the movable disk to achieve a water tight seal, the invention allows that certain areas of the contact surface of the valve seat disk be recessed and still allow sealing.

These improvements allowed the low cost stepper motor to be used, but perhaps even more significantly the improvements gave

a valve design that could be scaled up to industrial sizes and not require hugely expensive stepping motors.

An additional benefit was the ability to keep the cost of manufacturing the disks to a minimum when producing larger valves for industry. Ceramic disks are commonly used, but the cost to produce these increases exponentially relative to their diameter. This is because it takes extremes of temperature and pressure to produce a ceramic disk, and there are very few facilities in the world capable of producing the larger disks. All the improvements made while producing the domestic shower valve using the low cost printer stepping motor, paid significant dividends in the industrial versions of the valve.

The combination of the optimised disk geometry, the microprocessor based feed-back control system, and the use of a stepping motor for the actuator has produced a valve that is not only useful as a domestic shower valve, but is proving to be a significant step forward for industrial applications. The built in control system and feedback sensor mean that the valve is a simple "plug and play" unit that can be installed and is ready to go.

The valves are also achieving significantly improved control accuracy. This is in part due to the low friction, smooth and rapid operation of the valve components, and in part due to the built in electronic closed loop control system.

The affidavit presently being prepared by one of the inventors, Mr Peter Jeromson, provide a perspective on the development process of the present invention.

These aspects of the invention and the replacement (pending) claim set are next discussed with respect to each of the cited prior art documents.

**Prior art of IDS and Applied Art**

DE3832676 Braun

Braun teaches a valve having two movable disks, one to achieve flow control and one to achieve mixing control, and therefore the proposed claims of the present invention are clearly distinguished in that they claim a single movable disk.

US4653538 Tsutsui (A)

Tsutsui teaches a valve in which the fluid flow does not pass through the movable disk, but returns through additional apertures in the valve seat disk. Such an arrangement does not benefit from the minimised disk diameter design of the present invention. Torque requirements would be much greater, and the valve would not be as readily scaled up to suit industrial applications.

FR2524105 Ostertag

This patent teaches a valve disk surface design, and does not read on to the present invention.

US4610393 Rodrigues



Rodrigues teaches a valve which uses a pair of disks to control flow rate, and an additional thermostatically operated valve to control one of the input fluids so that temperature can be controlled. The operation of the valve is therefore clearly distinct from the present invention.

EP0297883 Newcombe

This patent teaches a fluid mixing apparatus which includes the use of two independent valves to control the flow of two input fluids. The revised claims of the present invention do not lay claim to valves of this nature.

US5358177 Cashmore

As with Newcombe, this patent teaches a fluid mixing apparatus which includes the use of two independent valves to control the flow of two input fluids. The revised claims of the present invention do not lay claim to valves of this nature.

US5504950 Natalizia

Natalizia teaches a mixing valve primarily for hand washing. A number of inlet apertures of different size are provided which provide incremental changes in output temperature. While such an arrangement may be acceptable for hand washing, it would not be suitable for most domestic shower and industrial uses, in which much finer temperature control is required. The geometry of the apertures, and the use of only one of a multiple number of apertures at a time, clearly means that the valve design does not enjoy the benefits of minimised disk diameter and

maximised aperture area of the present invention. The Natalizia invention would not be suitable for scaling up to industrial applications, and would not provide accurate enough control.

EP0272699 Tsutsui (B)

As with the earlier Tsutsui patent listed above, this patent teaches a valve in which the fluid flow does not pass through the movable disk, but returns through additional apertures in the valve seat disk. In addition the aperture geometry of this valve has been optimised to provide rapid cycling between hot and cold to produce a valve that is suitable for a hot/cold massage in a domestic shower situation. Such an arrangement does not benefit from the minimised disk diameter design of the present invention. Torque requirements would be much greater, and the valve would not be as readily scaled up to suit industrial applications.

US4431028 Hendrick

Hendrik teaches a rugged valve suitable for use on oil well heads. It controls flow only and does not control mixing, and is therefore distinctly different from the present invention.

US4673160 Tolley

Tolley teaches a valve which is adapted to independently divert a pair of fluid supplies for use in a hydraulic circuit. The patent does not teach mixing and is therefore distinctly different from the present invention.

EP0042523 Deloste et al

This patent teaches a flow control and mixing valve using two movable disks and is therefore distinctly different to the present invention which uses only one and therefore requires only a single actuator. The relative location of the disclosed apertures on a disk preclude the use of these disks in the present invention as it would not be possible to achieve both mixing and on-off control using disks as taught by Deloste.

US4761836 Tsutsui (C)

As with the earlier two Tsutsui patents listed above, this patent teaches a valve in which the fluid flow does not pass through the movable disk, but returns through additional apertures in the valve seat disk. Such an arrangement does not benefit from the minimised disk diameter design of the present invention. Torque requirements would be much greater, and the valve would not be as readily scaled up to suit industrial applications.

US3363536 Dean

Dean teaches a fluid flow control device, which does not achieve any mixing control and is therefore distinctly different from the present invention.

US3810602 Parkinson

Parkinson teaches a mixing faucet which uses two independent valves, the outputs of which flow together. The revised claims of the present invention do not lay claim to valves of this nature.

US4558817 Kiendl

As with Parkinson above, Kiendl teaches a mixing apparatus which uses two independent valves, the outputs of which flow together. The revised claims of the present invention do not lay claim to valves of this nature.

US4700885 Knebel

Knebel teaches a valve having two movable disks, one to achieve flow control and one to achieve mixing control, and therefore the proposed claims of the present invention are clearly distinguished in that they claim a single movable disk.

US4889315 Imanaga

Imanaga simply teaches a valve which is operated by an electric motor in response to a signal from a motion detector. The valve does not control mixing and does not use disks and is clearly distinguished from the present invention.

US5014748 Nogami et al.

This patent describes a hydraulic control valve which is designed to divert a pair of hydraulic fluid flows between two possible outlet paths. The valve does not achieve mixing control and is therefore distinguished from the present invention.

US5417083 Eber

Eber teaches a flow control valve and not a mixing valve. As with Deloste above, there is disclosed aperture geometry are similar to the present invention; however, the relative location of the apertures on the disk preclude the use of the Eber disks in the present invention as it would not be

possible to achieve both mixing and on-off control using the Eber disks.

US4611757 Saether

Saether teaches a valve with a movable disk design similar to the Tsutsui patents referred to above. However the Saether valve introduces a second axis of motion. Temperature control is achieved by a rotary motion of the movable disk, and flow control is achieved by a rectilinear motion. This valve is therefore clearly distinguished from the present invention in that it requires two actuators.

Furthermore, in the Saether valve the fluid flow does not pass through the movable disk, but returns through additional apertures in the valve seat disk. Such an arrangement does not benefit from the minimised disk diameter design of the present invention. Torque requirements would be much greater, and the valve would not be as readily scaled up to suit industrial applications.

If the disks of the Saether valve were to become stuck together, by dried salts for example as discussed above, the problem would be solved by the user exerting sufficient force on the handle to free the disk. This method of freeing a stuck valve is not available in industrial automated operations meaning that the Saether valve would not be suitable for scaling up to industrial sizes.

US3987819 Scheuermann

Scheuermann teaches a valve having two movable disks, one to achieve flow control and one to achieve mixing control, and therefore the proposed claims of the present invention are clearly distinguished in that they claim a single movable disk.

US4327758 Uhlmann

Uhlmann teaches a mixing and flow control valve having one moveable disk with two axis of motion - a rotary motion for temperature control and a rectilinear motion for flow control. Such an arrangement is clearly distinct from the present invention which has only one axis of motion. The disk aperture geometry is also distinctly different from the present invention and the valve could not be adapted to work in a similar fashion to the present invention.

US4243063 Parkinson

Fundamentally the Parkinson valve is very similar in design to the Tsutsui valves discussed above. One difference being the siamesed outlet port on the Parkinson valve, providing alternate paths to either a shower head or a faucet outlet.

As with the Tsutsui patents, this patent teaches a valve in which the fluid flow does not pass through the movable disk, but returns through additional apertures in the valve seat disk. Such an arrangement does not benefit from the minimised disk diameter design of the present invention. Torque requirements would be much greater, and the valve would not be as readily scaled up to suit industrial applications.

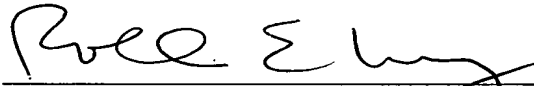
Summary

As discussed above, the prior art neither teaches nor suggests the invention as recited by the newly presented claims. Therefore, reconsideration and allowance of all the claims are respectfully requested.

The Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 25-0120 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17.

Respectfully submitted,

YOUNG & THOMPSON



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**APPENDIX:**

The Appendix includes the following item(s):

- Replacement Sheets for Figures 1-13 of the drawings
- a Substitute Specification and a marked-up copy of the originally-filed specification
- an affidavit





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## VALVE SYSTEM FOR SERVO CONTROL OF FLUID FLOWS

The present invention relates to valves for controlling the flow of fluids in a fluid supply system. More particularly, it relates to valves suitable for active servo control of fluid flows. Further, in particular, it relates to valves for active servo control of fluid flows in a fluid mixing unit.

### BACKGROUND OF THE INVENTION

Valve systems suitable for being electrically controlled and actuated are known for a wide variety of applications. These add the many advantages of control electronics and computing to their applications.

One such application, is the control of flow for shower mixers, hand basin mixers, and the like.

A commonly used conventional electrically controllable flow valve includes a conventional faucet valve and an electric motor to actuate the spindle of the faucet valve. The electric motor turns the spindle to axially move the disc of the faucet valve and restrict flow emerging from the disc ring of the faucet valve. Typically, multiple revolutions of the spindle are required to actuate the disk through its working range. Also the spindle is mounted and moved by means of a thread arrangement which introduces friction. Therefore, this type of valve is not well suited to servo control. Also, movement of the disk to close the valve must work against the supply pressure of the fluid.

Accordingly, it is an object of the present invention to provide a fluid control valve which overcomes or obviates the disadvantages of existing systems, or at least to provide the public with a useful choice.

It is also an object of an embodiment of the present invention to provide a fluid control valve adapted to servo control the flow of fluid through the valve, or at least to provide the public with a useful choice.

It is an object of an embodiment of the present invention to provide a servo controlled mixing of supplied fluids in given ratios, or at least to provide the public with a useful choice.

It is an object of an embodiment of the present invention to provide an actively controlled shower mixer which employs temperature feedback, or at least to provide the public with a useful choice.

### **SUMMARY OF THE INVENTION**

Accordingly, in a first aspect, the invention may broadly be said to consist in a fluid mixing valve suitable for servo control of fluid flows, comprising: a valve body having at least two fluid inlet ports and at least one fluid outlet port; a valve seat having a valve seat contact surface and an outlet valve member having an outlet member contact surface, the valve member being rotatable about a first axis; said valve seat having two adjacent inlet apertures there through separated by a dividing piece, and said valve seat having a closed area opposite the inlet apertures, a first said inlet aperture communicating with a first of said two inlet ports, and a second said inlet aperture communicating with a second of said two inlet ports, a barrier on the inlet side of the valve seat separating the fluid flow from said at least two inlet ports so that the two supplies of fluids do not mix until after they have passed through the two inlet apertures in the valve seat; said valve member having an outlet aperture there through and a sealing area, said outlet aperture communicating with said at least one outlet port, the valve member contact surface and the valve seat contact surface being arranged in substantially planar sealing contact with one another, and the valve member is capable of rotation relative to the valve seat, wherein the outlet aperture of the valve member is substantially sector shaped at the plane of the valve member contact surface, with its sector apex at or close to the point of intersection of the first axis with the valve member and with

its arc at or close to the outside of the valve member, and the two adjacent inlet apertures of the valve seat are each substantially sector shaped at the plane of the valve seat contact surface with each having its sector apex close to the point of intersection of the first axis with the valve seat, and the sealing area of the valve member is greater than or equal to the combined area of the two adjacent inlet substantially sector shaped apertures so that the sealing area of the valve member can cover and close the two adjacent inlet substantially sector shaped apertures, whereby the valve member can be rotated about the first axis between a shut off position where both of the inlet apertures are closed by the valve member, a first inlet opened position where the first inlet aperture and the outlet aperture are aligned to allow fluid to flow from the first inlet port through the first inlet aperture via the outlet aperture to the outlet port, whilst at the same time the second inlet aperture is closed by the valve member, a second inlet opened position where the second inlet aperture and the outlet aperture are aligned to allow fluid to flow from the second inlet port through the second inlet aperture via the outlet aperture to the outlet port, whilst at the same time the first inlet aperture is closed by the valve member, and a mixing position wherein the outlet aperture overlaps with both of the inlet apertures to allow fluids to flow from said two inlet ports through the two inlet apertures and through the outlet aperture, and mix downstream of the outlet aperture so that the fluids can exit the outlet port.

Preferably the valve member is a first valve disk.

Preferably the valve seat is a second valve disk and has an opposing surface on the other side of the disk from the contact surface.

Preferably the two adjacent inlet apertures of the second valve disk have a greater area in the plane of the contact surface of the second

valve disk than in the plane of the opposing surface of the second valve disc.

Preferably the substantially sector shaped outlet aperture of the valve member at the plane of the valve member contact surface has an angle of about 120 degrees at its apex.

Preferably the two adjacent substantially sector shaped inlet apertures of the valve seat at the plane of the valve seat contact surface, each have an approximately 90 degree apex.

Preferably the outlet aperture in the valve member is in the shape of a removed sector.

Preferably the valve seat contact surface has a recessed region.

In a second aspect, the invention may broadly be said to consist in a servo actuated fluid mixing valve, comprising: a valve body having at least two fluid inlet ports and at least one fluid outlet port; a servo actuator attached to said valve, a valve seat having a valve seat contact surface and an outlet valve member having an outlet member contact surface, the valve member being capable of being rotated about a first axis by said servo actuator, said valve seat having two adjacent inlet apertures there through separated by a dividing piece, and said valve seat having a closed area opposite the inlet apertures, a first said inlet aperture communicating with a first of said two inlet ports, and a second said inlet aperture communicating with a second of said two inlet ports, a barrier on the inlet side of the valve seat separating the fluid flow from said at least two inlet ports so that the two supplies of fluids do not mix until after they have passed through the two inlet apertures in the valve seat; said valve member having an outlet aperture there through and a sealing area, said outlet aperture communicating with said at least one outlet port, the valve member contact surface and the valve seat contact surface

being arranged in substantially planar sealing contact with one another, and the valve member is capable of rotation relative to the valve seat, wherein the outlet aperture of the valve member is substantially sector shaped at the plane of the valve member contact surface, with its sector apex at or close to the point of intersection of the first axis with the valve member and with its arc at or close to the outside of the valve member, and the two adjacent inlet apertures of the valve seat are each substantially sector shaped at the plane of the valve seat contact surface with each having its sector apex close to the point of intersection of the first axis with the valve seat, and the sealing area of the valve member is greater than or equal to the combined area of the two adjacent inlet substantially sector shaped apertures so that the sealing area of the valve member can cover and close the two adjacent inlet substantially sector shaped apertures, whereby the valve member can be rotated about the first axis between a shut off position where both of the inlet apertures are closed by the valve member, a first inlet opened position where the first inlet aperture and the outlet aperture are aligned to allow fluid to flow from the first inlet port through the first inlet aperture via the outlet aperture to the outlet port, whilst at the same time the second inlet aperture is closed by the valve member, a second inlet opened position where the second inlet aperture and the outlet aperture are aligned to allow fluid to flow from the second inlet port through the second inlet aperture via the outlet aperture to the outlet port, whilst at the same time the first inlet aperture is closed by the valve member, and a mixing position wherein the outlet aperture overlaps with both of the inlet apertures to allow fluids to flow from said two inlet ports through the two inlet apertures and through the outlet aperture, and mix downstream of the outlet aperture so that the fluids can exit the outlet port.

Preferably the servo actuator includes a stepping motor.

Preferably the servo actuated fluid mixing valve further includes a controller means.

Preferably the servo actuated fluid mixing valve further includes a sensing means which is positioned and adapted to sense at least one parameter relating to any fluid which passes through the at least one fluid outlet port, allowing feed-back control of the valve.

Preferably the servo actuated fluid mixing valve further includes a controller means.

Preferably the servo actuator includes a stepping motor.

Preferably the servo actuated fluid mixing valve further includes a user interface means.

Preferably the valve member is a first valve disk.

Preferably the valve seat is a second valve disk and has an opposing surface on the other side of the disk from the contact surface.

Preferably the two adjacent inlet apertures of the second valve disk have a greater area in the plane of the contact surface of the second valve disk than in the plane of the opposing surface of the second valve disc.

Preferably the substantially sector shaped outlet aperture of the valve member at the plane of the valve member contact surface has an angle of about 120 degrees at its apex.

Preferably the two adjacent substantially sector shaped inlet apertures of the valve seat at the plane of the valve seat contact surface, each have an approximately 90 degree apex.

Preferably the outlet aperture in the valve member is in the shape of a removed sector.

Preferably the valve seat contact surface has a recessed region.

~~According to an aspect of the present invention there is provided a valve body; a first member defining at least one first aperture communicating with at least one respective fluid supply or outlet; and a second member defining at least one second aperture; wherein the first and second members are arranged in sealing contact and are variably alignable so that first and second apertures are, in turn, variably alignable such that fluid may flow through the at least one first aperture only when there is an overlap between first and second apertures, and such that the flow through the or each second aperture may be varied by variable alignment of the first and second apertures.~~

~~Preferably, the first and second members are variably alignable by rotation. Preferably, this rotation may be actuated by a stepper motor which may be controlled by a controller including a microprocessor, preferably, receiving parameter feedback from at least one sensor.~~

~~According to another aspect of the present invention, there is provided a fluid control valve communicating with at least two fluid supplies, including:~~

- ~~o at least two valve subunits, each subunit including a first member having at least one first aperture and a second member having at least one second aperture, and wherein fluid flow from the at least one first aperture is controllable by variable alignment of the first and second members;~~
- ~~o at least one electric motor, preferably a stepper motor, arranged to actuate the variable alignment of first and second members for one or more valve subunits.~~

~~Preferably, the valve includes a controller including a microcontroller which may receive parameter feedback from at least one sensor.~~

~~According to another aspect of the present invention, there is provided a fluid control valve as claimed in any one of the preceding claims, including a single first aperture and at least two second apertures arranged such that variable alignment of the first and second members allows variable diversion of fluid through each of the at least two second apertures.~~

~~According to another aspect of the present invention, there is provided a fluid control valve including at least two outlets; at least two fluid control valves as immediately above, wherein one second aperture of each fluid control valve communicates with one or the other of the two outlets.~~

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

- FIGURES 1 & 1A:**                      Respectively show top and bottom views of a part of a valve in accordance with an embodiment of the present invention.
- FIGURE 2:**                              Shows a side view of the part shown in Figures 1 and 1 A.
- FIGURE 3:**                              Shows a plan view of another part of a valve according to the same embodiment of the present invention.
- FIGURE 4:**                              Shows a side view of the parts shown in Figure 3.
- FIGURE 5:**                              Shows a part of a valve corresponding to the parts shown in Figures 1 and 2 according to an alternative embodiment of the present invention.



- FIGURE 6:** Shows a side plan view of a part shown in Figure 5.
- FIGURE 7:** Shows a gasket which corresponds to the part of the valve shown in Figures 1, 1 A and 2.
- FIGURE 8:** Shows a side view of the gasket shown in Figure 7.
- FIGURES 9 & 9A:** Shows part of a gasket used to seal either of the parts shown in Figures 1 and 2 or 5 and 6.
- FIGURES 10 & IOA:** Shows two reinforcement members for the gasket shown in Figure 9;
- FIGURE 11:** Shows a valve assembly incorporating the parts shown in Figures 1 to 10 of either embodiment.
- FIGURE 12:** Shows a servo valve system according to an embodiment of the present invention and incorporating the valve assembly shown in Figure 11.
- FIGURE 13:** Shows a servo valve system according to an alternative embodiment and incorporating the valve assembly shown in Figure 11.
- FIGURE 14:** Shows a servo valve system according to an alternative embodiment of the present invention.
- FIGURE 15:** Shows the layout of a user interface for a servo valve system according to an

alternative embodiment of the present invention.

**FIGURE 16:**

Schematically shows a mixing system according to an embodiment of the present invention.

**FIGURES 17-20:**

Show a combination mixing and diverting servo valve system according to a further embodiment of the present invention.

**DETAILED DESCRIPTION OF THE DRAWINGS**

Figures 1, 1A and 2 show an inlet valve member 1 which, in use, is aligned perpendicular to a flow of fluid through the valve. The inlet valve member 1 includes two apertures ~~conduits~~ 2 and 3 through which fluid passes when the valve is open. Typically, these apertures ~~conduits~~ 2 and 3 have a cross section that is sectorial or elliptical at one face of the valve member 1 and circular at the other, although any suitable cross sectional shape may be substituted. The apertures 2 and 3 are, typically, formed circular at the face of the inlet valve member 1 which is in contact with the fluid supply and the size of the circles are minimised, within constraints of required flow. In use, only the apertures 2 and 3 and a minimal area around the apertures are in contact with the fluid supply to minimise pressure being exerted on the inlet valve member 1 which would increase friction between the inlet valve member 1 and ~~an~~ the outlet valve member 10, described with reference to figure 3 below. Also, typically, the apertures ~~conduits~~ 2 and 3 are positioned inward from the periphery of the valve member 1 to provide an area of the valve member 1 peripheral to the apertures ~~conduits~~ against which another member may abut to seal the ~~conduits~~ apertures 2 and 3 when required. However, suitable alternative sealing arrangements will be apparent to those skilled in the art.

The apertures ~~conduits~~ 2 and 3 may have different relative sizes to account for relative differences in supply pressures or viscosity, for example.

The inlet valve member may typically have a recessed region 5 formed in the contact side 6 of the inlet valve member 1 and grooves 6a to reduce friction with any flat surface in contact with the contact side 6 of the inlet valve member 1. Such friction reduction measures reduce the actuation torque required by the valve. The edges of the inlet valve 1 may, typically, be bevelled to prevent chipping of the edges of the valve member 1.

The inlet valve member includes alignment tabs 7 with which it may be held in a given orientation.

Figures 3 and 4 show an ~~the~~ output-outlet valve member 10. The valve member 10 has a contact surface 11 which may be flat so that the ~~output-outlet~~ valve member 10 may be sealingly abutted against the contact side 6 of the inlet valve member 1 in use to seal the ~~conduits~~apertures 2 and 3 when required.

The ~~output-outlet~~ valve member 10 is of the form of a disk with a removed sector 12. It will be apparent to those skilled in the art that alternative shapes to ~~the~~ removed sector 12 may suitably be substituted and that the shape may be optimised for particular applications. In use, the ~~output-outlet~~ valve member 10 is abutted and aligned with the inlet valve member 1 and depending on its orientation with respect thereto, variably impedes the flow of fluid emerging from the ~~conduits~~apertures 2 and 3. The flow will be completely impeded and the ~~conduits~~apertures 2 and 3 sealed when the ~~cutout portion~~removed sector 12 of the ~~output-outlet~~ valve member 10 does not overlap either of the ~~conduits~~apertures 2 or 3. The flow of fluid through each of the ~~conduits~~apertures 2 and 3 can be varied from nil flow to an unimpeded flow or a controlled ratio of flow through each conduit. Thus, the ~~output-outlet~~ valve member 10 and input valve member 1 may be combined to form a mixing valve. Alternatively, they may be reversed and combined to form a diverting valve. Alternatively, an inlet valve member 1 having only one aperture may be used to control the flow

of a single fluid, or both apertures of the inlet valve member 1 may communicate with a single fluid supply for the same purpose.

Typically, each aperture~~conduit~~ 2 and 3 communicates with a separate fluid supply conduit, not shown, and the output of the valve communicates with a single output conduit so that the valve allows the variable mixing of the fluids from the two supply conduits.

The ~~output-outlet~~ valve member 10 includes actuation recesses 13 by which it may be rotated.

The size of the removed~~cutout~~ sector 12 in conjunction with the size of the apertures 2 and 3 determines the maximum flow rate for given fluids at given temperatures and pressures.

Figures 5 and 6 show an alternative inlet valve member 1 which includes ~~conduits~~apertures 2 and 3 having a sectorial cross-section of greater area than those of the inlet valve member shown in Figures 1 and 2. It will be clear to those skilled in the art that other conduit sizes and shapes may be substituted as applicable to given applications of the valve.

Figures 7 and 8 show a seal, or gasket, 85 used in conjunction with the inlet valve member 1 shown in Figures 1, 1A and 2. The use of the gasket 85 is explained with reference to Figure 11 below.

~~Figures 7 and 8 show a gasket 85 used to seal the inlet valve member 1 shown in Figures 1, 1A and 2.~~

Figures 9 to 120a show alternative gasket elements 28 and 29, which are combined to form a gasket for sealing inlet valve members 1 shown in Figures 5 and 6. The gasket selements 28 are, typically, formed from silicon, rubber or other suitable deformable material, and gasket

~~members~~elements 29 are, typically, formed from plastic and serve the purpose of reinforcing the gasket ~~member~~element 28.

Figure 11 shows a valve assembly 19, including the inlet valve member 1 and outlet valve member 10 of either of the embodiments described above. These valve members are fitted inside a valve chassis 20. The ~~cut-away~~removed sector 12 of the outlet valve member 10 and the valve chassis 20 define an outlet aperture. The valve chassis 20 is open at one end to form a valve chassis inlet 21. A valve chassis outlet 22 is formed in the side of the valve chassis 20. In use, the valve assembly 19 is fitted into a valve housing 35~~valve housing~~ as described with reference to figure 12 below. An O-ring 23 is used to seal the valve assembly 19 in the valve housing 35.

The valve assembly 19 includes a spindle assembly 24, which engages the actuation recesses 13 of the outlet valve member 10. The outlet valve member 10 can be rotated by rotation of the spindle assembly 24, which includes a spline 25 formed at one end to facilitate turning of the spindle assembly 24.

The inlet valve member 1 is, typically, held in fixed alignment by the alignment tabs 7 which engage corresponding alignment recesses, not shown, in the valve assembly chassis 20. The spindle assembly 24 is sealed within the valve assembly chassis 20 by use of O-rings and washers.

The gasket 85 or that formed from gasket members 28 and 29 is fitted into the inlet end of the valve assembly chassis 20.

The working of the valve assembly is illustrated below with reference to hot and cold water, each being supplied by one separate conduit 2 or 3, as would be the case with an application such as a shower temperature control mixing valve.

The ~~output-outlet~~ valve member 10 is initially orientated so as to cover or seal both of the apertures 2 and 3 of the inlet valve member 1.

The spindle 24 is then turned in an opening direction to initially uncover part of the aperture 2, for example, which is supplied with cold water. Continued turning in the same direction increasingly uncovers the aperture 2. Eventually, continued turning will uncover the other aperture 3 to which hot water is supplied and partially cover the aperture 2. The ratio of hot and cold water may be adjusted by turning the spindle 24 in the same direction or in the opposite direction. Having sectorial inlet and outlet apertures, provides that the valve has a substantially linear flow response with respect to rotational angle.

At a mid point, equal portions of each aperture are uncovered and depending on the chosen shape and size of the ~~conduits~~apertures 2 and 3 and sector 12, this may correspond to partial covering of both apertures 2 and 3.

Further turning may result in only the aperture 3 being uncovered and only hot water being supplied to the valve ~~assembly~~chassis outlet 202.

Figure 12 shows a side view of a servo valve system 30, which includes the valve assembly 19 described above.

The servo valve system 30 also includes an inlet manifold 31 having two inlets 32, one of which ~~32~~ is shown cross-sectionally in Figure ~~13~~, 12 and the other of which is positioned directly behind ~~at~~the dividing wall 33, as shown in Figure ~~13~~12. ~~The~~A dividing piece 8 of the inlet valve member 1, which divides the two apertures 2 and 3 is aligned with the dividing wall 33. The gasket 28 or 85~~6~~ is aligned accordingly. It may be preferable that the gasket 26~~8~~ or the inlet manifold 31 are shaped like gasket 85 so that only the apertures of the inlet valve member 1 are in contact with the fluid supply as otherwise force exerted on the inlet valve member 1 causes increased friction between the inlet valve member 1 and the outlet valve member 10 which requires an increase actuation torque.

The servo valve system 30 includes an outlet pipe 34 connected at the outlet 22 of the valve assembly 19. Typically, but not necessarily, the outlet pipe 34 is integrally formed from the servo valve system housing 35.

The valve assembly 19 is secured in the housing 35 with an annular cap 36 and sealed at the top with the O-ring 23.

The inlet manifold 31 is sealed to the housing 35 with an O-ring 37.

The servo valve system 30 includes a stepper motor 38, or some other automated driving device such as a DC motor, AC motor or hydraulic motor, to actuate the spindle 24 at the spline 25 through a gear box 39. It will be apparent to those skilled in the art that a wide variety of stepper motors may be used with suitable gear boxes or that a spline 25 of suitable diameter may eliminate the need for a gearbox 39 in some cases. By the use of the friction reducing measures described above, a minimally sized stepper motor may be used reducing the size and required resources of the device.

The servo valve system 30 may include one or more sensors, not shown, in the input manifold 31, but more particularly in the outputlet pipe 34 to provide feedback for the control of the servo valve system 30.

The sensors may include temperature sensors. For example, a thermistor may be inserted through the side of the outlet pipe 34 to monitor temperature of the water, say, in the outlet pipe 34 and to allow suitable adjustment by the stepper motor 38 to control temperature of water in the outlet pipe 34 in the case where different temperature fluid supplies are connected to the inlet manifold 31.

Figure 13 shows a servo valve system 40 according to an alternative embodiment of the present invention. The servo valve system 40 differs from the servo valve system 30 described above, only by the inclusion of an extra output pipe 41 which may be opened or closed by way of a solenoid valve 42. In one application, the outputlet pipe 34 supplies a hand held shower head and the output pipe 41 supplies a midriff height shower jet. The solenoid valve 42 opens and closes water supplied to the hand held shower head as desired.

Figure 14 shows a side view of a servo valve system 50 according to another aspect of the present invention.

The servo valve system 50 includes two individual valves such as 51 shown each being supplied by individual inlet pipes, such as 52 shown.

The valves consist of conventional apertured ceramic disks mounted in a chassis with two outlets on opposite sides of the chassis.

The ceramic disks each include two opposing apertures, typically sectorial in shape. To open the valve, one of the disks is rotated by way of the spindle so that the apertures of both disks overlap.

The outlets of both valve assemblies feed a single intermediary conduit 55. Each valve is actuated at the respective spline 54 of the respective spindle 53 by a respective gearbox ~~respective~~ 61 and a respective stepper motor 62.

As each valve controls the inflow of fluid from a separate inlet, the ratio of fluids from each inlet as well as the total flow from both inlets can be adjusted.

Typically, the stepper motors are controlled such that once a desired flow in the intermediary pipe 55 is achieved, an adjustment to one valve is accompanied by a negative adjustment of the other, so that the mix of fluid in the intermediary pipe 55, or temperature, can be adjusted whilst the pressure is maintained. This may be modified to take account of relative differences in supply pressures that occur where non mains pressure water supply systems are used.

The servo valve system 50 also includes an outlet manifold 56 which, typically, has ~~three~~ two final outlets such as 57 and 58, each including a solenoid valve such as 59 and 60.

One embodiment incorporating this aspect of the present invention is intended for use with a shower unit, which has two fixed shower heads, one at head height and one at ~~mid~~ midriff ~~drift~~ height, for example. This embodiment is supplied with hot and cold water at separate inlets and includes a thermistor inserted into the intermediary chamber 55 to provide



feedback on temperature for appropriate control of the two valves such as 51. Thus, a drop in one or the other of the water supplies will be compensated in terms of temperature without the need for a pressure feedback, although this may be included if desired.

This embodiment is able to compensate for changes in supplied pressure of either or both the hot and cold water so that a constant desired temperature and constant desired pressure is provided at the shower heads. It may also compensate for changes in pressure at one or two of the final outlets such as 57 and 58 in the event that one or two of the other final outlets are opened or closed.

One preferred embodiment of the present invention is directed for use in bathroom showers where it provides relatively constant temperature water for shower heads. It will be clear to those skilled in the art that the bathroom shower is merely an example application and that many analogous applications of this embodiment exist and that the mixing of water of different temperatures may be analogous to the mixing of fluids having other physical or chemical properties. A few examples are pH, viscosity, dielectric constant, or content of a given chemical or biological agent.

The bathroom shower mixing system is supplied with two fluids, hot and cold at given pressures. These are mixed by a servo valve system according to any of the embodiments described above and information on the temperature of the mixed fluid is fed back to the controller of the servo valve system. In the case of the servo valve system 50 being used, information on pressure can be estimated by the known position of the stepper motors and so pressure may be maintained.

The temperature sensors are typically negative temperature coefficient sensors. Some inherent nonlinearity of the temperature signals may be partially compensated with the sensor electronics before quantisation by the microprocessor. The microprocessor contains software that compares the measured temperature with a predefined reference

temperature. From this, and with an appropriate control algorithm, again, the microprocessor determines the required position of the stepper motors, and therefore, the valve members 1 and 10. It will be understood by those skilled in the art that calibration of the system will be necessary and suitable calibration will be apparent.

To maintain excellent speed and torque characteristics whilst maintaining good angular resolution and minimal microprocessor resource, the stepper motors are, preferably, operated at two speeds using two different stepping modes.

The motor is "full-stepped" for large displacements. This optimises the speed and torque response.

The motor is "half-stepped" for temperature adjustments. This optimises the resolution of movements.

The motors are half-stepped at the start of an acceleration from rest and later full-stepped. Similarly, the motors are half-stepped at the end of a deceleration to rest and after full-stepping. These measures reduce mechanical shock and overcome inertia of the motor, gearbox and valve assembly.

The mixer system also includes protection against the valve being left open in the event of loss of electrical power. Two methods are employed in the preferred embodiment. One method includes the use of batteries which store enough energy to close the valve assembly when power loss is detected. The other method includes the use of solenoids that require power to remain open and, thus the flow is shut off when the power fails.

Figure 15 shows a user interface 60 for a preferred embodiment of the bathroom shower mixing system that includes the servo valve system 50.

The user interface 60 includes an LCD display 61 for displaying the desired and/or actual water temperature and  $\pm$  62-button system 62 for adjusting the desired water temperature.

A set of three buttons 63 are also included to switch on/off a shower rose, perhaps, fixed at head height, shower jets, perhaps, fixed at midriff height and a hand held shower rose. The set of buttons 64 are included for user programmable preset functions for, perhaps, temperature and combinations of outlets and lights. Button 65 controls an economy mode which may reduce water flow by 25% or 50%. Button 66 may be used to set the shower duration with increments of 30 seconds. Button 67 switches on/off a "Swedish" cycle which fluctuates the shower temperature between hot and cold.

Figure 16 schematically shows the operation of a servo valve system in accordance with an embodiment of the present invention.

Information on a desired value of a given parameter, such as temperature of fluid leaving the valve system, is received from the user interface 71. This information is fed to the system controller 72. The system controller 72 receives information from a sensor at the output of the valve system and includes an analogue to digital converter 73 to quantify the parameter value sensed by the sensor. The position of the stepper motor and gearbox 75 is then calculated by the ~~module~~-microcontroller 74 and then converted to a stepper sequencer 81. The stepper motor and gearbox 75 are then driven by the stepper driver 76 to the required position. By actuation of the stepper motor and gearbox 75, the mixing assembly 77 is placed in a suitable position to mix the inlet fluids 78 and 79 to form ~~the~~-an outlet fluid 80. Information on the given parameter is then fed back to the microcontroller 74 and the process repeated by way of adjustment.

It will be apparent to those skilled in the art that an alternative embodiment to those described above may include a valve assembly 19 used in reverse where water is fed into the outlet 22 from a single supply

and from there diverted into either of the ~~conduits~~apertures 2 or 3 of the, now, outlet member 1.

Figures 17 to 20 show a further embodiment of the present invention. This is a combined valve provided to control temperature, pressure and also direct flow between alternative outlets. The fluid control valve 90 shown in Figures 17 to 20 may control the flow of hot and cold water independently to alternative outlets. The valve 90 may comprise a main body portion 91 having hot and cold water inlets 92 and 93 respectively. Valve members 94 and 95 may be provided in cooperating pairs acting to independently control the flow of hot and cold water respectively. These cooperating pairs may be prepared as pairs of valve members in accordance with valve members 1 and 10, although it will be preferable that the inlet valve member/and outlet is valve member 10 are swapped so that the "outlet" valve member 10 now communicates directly with the fluid supply.

It can be seen that the outlet from the valve members 94 and 95 allows flow into either one of two mixing chambers 96 and 97, each connected with separate outlets 98 and 99. Further, control of the valve members 94 and 95 and the relative rotation of one with the other is provided by stepper motors 100 and 101. These stepper motors may be controlled by a controller which may receive feedback information on temperature, or some other fluid parameter, at the outlet.

It can be seen that a valve of this type may be mounted on an installation to divert flow between a shower head or a bath spout, for example. The temperature at the outlet may be controlled through independent control over the flow of hot and cold fluid into the mixing chambers through the valve members 94 and 95 by control of the stepper motors 100 and 101. Furthermore, if the valve members 94 and 95 are independently controlled, the flow rate from the valve may be controlled by controlling the degree to which each of these valve members are opened.

This assembly allows servo control over the direction, flow rate and fluid temperature ~~fluid~~ in a single installation.

In all the valve assemblies filters may be incorporated either within the valve or upstream to inhibit the entry of particulate matter into the valve which may affect the valve control.

Although the above described embodiments have been described in reference to the mixing of two fluids, it will be apparent to those skilled in the art that the valve or valve systems may find useful application in controlling the flow of a single fluid and that this is merely a simpler application than controlling the flow of two fluids. One possible example of a single fluid application is in the control of water supplied to a urinal. For single fluid applications, the valve member 1 described above may be used with both apertures 2 and 3 communicating with a single fluid supply. An alternative embodiment includes an inlet valve member, not shown, similar to the inlet member 1, but consisting of only one inlet aperture.

The present invention provides an effective servo valve system which can actively compensate for fluctuations in relative supply of two or more fluids. This may, for example, be desirable for shower mixers where the hot and cold water supply pressures may fluctuate due to use in another part of a building, for example.

Another embodiment of the present invention provides a servo valve system, which may actively adjust, for flow or relative and absolute changes in the supply pressure of two or more supplied fluids. This may, for example, be useful for shower mixing units where constant flow as well as constant temperature is desired. This may be particularly useful where the shower mixer has multiple outlets and adjustment of supply pressure is necessary to compensate for sudden changes in outflow through the outlets.

The present invention provides servo control valve systems which incorporate stepper motors which are, by their nature, suited to servo control applications and eliminate the need for systems for monitoring the position of the valves or motors.

Where in the foregoing description, reference has been made to specific components or integers of the invention having known equivalents then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example and with reference to possible embodiments thereof, it is to be understood that modifications or improvements may be made thereto without departing from the scope or spirit of the invention, as defined in the appended claims.